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Applications-Driven Novel Laser Materials and Devices*

by

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ABSTRACT

High-power laser-diode pump arrays have recently revolutionized solid-state laser design and device performance. Simply replacing the pump lamp in a conventional solid-state laser, such as Nd:YAG, has resulted in a many-fold increase in efficiency and brightness (beam quality), and in a many-fold decrease in laser size, weight, and utilities demand. During the last half-decade, we (at LLNL) have sought to significantly broaden the utility and application of high-power laser-diode pump arrays through the coordinated development of new types of laser gain media, micro-optic pump-coupling elements, pump-array micro-cooling systems, and novel laser device architectures. This paper will discuss three new families of diode-pumped solid-state laser crystals that have resulted from our work: 1) tunable chromium (3+) doped colquiriites (e.g., Cr:LiSAF), 2) ytterbium (3+) doped apatites (e.g., Yb:S-FAP), 3) tunable chromium (2+) doped chalcogenides (e.g., Cr:ZnSe). Each of these laser materials offers a unique and decisive capability relative to previously known solid-state laser materials:

1) Cr:LiSAF typifies a broadly-tunable solid-state laser that can be directly pumped with red InGaAlP laser diode arrays (and can be operated in a wide variety of output waveforms, CW, Q-switched, mode-locked, etc.).

2) Yb:S-FAP typifies an InGaAs pumped gain medium, with pump and laser transition cross-sections (saturation fluxes) that are an order of magnitude greater (smaller) than all other known Yb-laser materials. These unique spectroscopic features permit very efficient (>25%) quasi-three-level laser operation at room temperature with very low pump intensities.

3) Cr:ZnSe typifies a wholly new class of broadly-tunable mid-infrared (2-3 microns) solid-state lasers that can be directly pumped with mid-IR InGaAsP laser diode arrays (and operate as does the titanium doped sapphire laser).

The talk will outline the technical considerations invoked to establish target laser spectroscopic and bulk crystal properties of these novel laser gain media and the considerations utilized in guiding our search for laser crystal types possessing the desired characteristics. The current technical status of each of these materials systems will be briefly summarized.

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